BBSUCT1004 (Environmental Sciences)

Question Bank:

Unit1: (CO1):

1. What do you mean by internal treatment for water softening?

Softening (Conditioning) Methods

Water used for industrial purposes should be free from hardness-producing salts, suspended impurities, dissolved gases, etc., The processof reducing hardnesslevel by removing the hardness causing salts from water is known as Softening or conditioning of water. Softening can be achieved by

a)Internaltreatment

b)Externaltreatment

Internal Treatment (Internal Conditioning) of Boiler Water

Internal treatment involves the addition of chemicals directly to the water in the boilers for removing scale forming substances which were not completely removed in the external treatment. The chemicals added for this purpose are called Boiler compounds.

i) Colloidal Conditioning

Scale formation can be avoided by the addition of colloidal conditioning agents like kerosene, glue, agar – agar and gelatin. It is used in low pressure boilers. The colloidal substances get coated over the scale forming particles and convert them into sludge, which can be removed by blowdown operation.

ii) Carbonate Conditioning

Scale formation can be avoided by adding Na_2CO_3 to boiler water. Scale forming salts like $CaSO_4$ are converted into $CaCO_3$ which can be easily removed.

$CaSO_4 + Na_2CO_3 \rightarrow CaCO_3 + Na_2SO_4$

iii) Phosphate Conditioning

An excess of soluble phosphate is added to the boiler water , react with Calcium ions & Mg salts to form a non-adherent precipitate of calcium phosphate and magnesium phosphate and thusthe scale formation is prevented.

$CaSO_4 + 2Na_3PO_4 \rightarrow Ca_3(PO_4)_2 + 3\ Na_2SO_4$

Generally 3 types of phosphates are employed

a) Trisodium phosphate: Used forstrongacidic water

b) Disodium hydrogen phosphate: Used for weakly acidic water

c) Sodium dihydrogen phosphate: Used for alkalinewater

iv) EDTA Conditioning

Phosphate treatment fails to prevent the formation of iron oxide and cuprous depositions(iron phosphate).Theconditioning ofboiler waterwith complexingagentssuch as EDTA and its disodium salt(Na_2EDTA) will prevent the formation of scale & sludges and also protect the boilerfromcorrosion.

2. Explain the disadvantages of hard water in domestic as well as industries.

Draw backs (or) Disadvantages of Hard Water

Domestic Use

1. Washing
2. Bathing
3. Drinking
4. Cooking

The sticky precipitate adheres on the fabric/cloth and gives spots and streaks. Fe salts stain the cloths.

Produces sticky scum on the bath tub and the body

Bad to the digestive system and calcium oxalate formation is possible in urinary tracts

Requires more fuel and time. Certains food don't cook soft and also gives unpleasant taste

Industrial Use

1. Textile Industry : wastage of soap
2. Sugar Industry : difficulty in crystallization of sugar
3. Dyeing Industry : imperfect shades or uneven spots
4. Paper Industry
5. Pharmaceutical Industry
6. In Steam generation in Boilers

3. Make use of Zeolite process how does hardness of water can be removed? Discuss its merits and demerits.

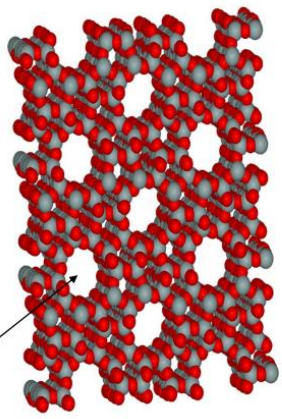
Zeolite (Permutit) method of Softening of water

Zeolite is a Hydrated Sodium Alumino Silicate, capable of exchanging its sodium ions with hardness producing cations in water.

The general chemical structure of zeolite is given below

$Na_2O.Al_2O_3.xSiO_2.yH_2O$

(x = 2-10 and y = 2-6)



Micro pores of Zeolite

Porous Structure of zeolite

Process of softening by Zeolite method

Zeolite can be simply represented as Na_2Ze, where Ze represents insoluble radical which holds sodium ions loosely. When hard water is passed through Zeolite, Ca^{2+} and Mg^{2+} ions are retained by zeolite as CaZe and MgZe.

To remove temporary hardness

$$Na_2Ze + Ca(HCO_3)_2 \longrightarrow CaZe + 2NaHCO_3$$

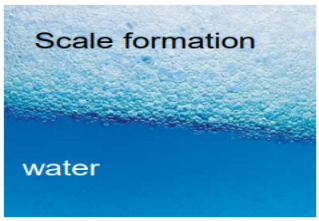
Hardness

$$Na_2Ze + Mg(HCO_3)_2 \longrightarrow MgZe + 2NaHCO_3$$

To remove permanent hardness

$$Na_2Ze + CaCl_2 \longrightarrow CaZe + 2NaCl$$

$$Na_2Ze + MgSO_4 \longrightarrow MgZe + Na_2SO_4$$



Regeneration of Zeolite Bed

After some time zeolite bed gets exhausted. Which is regenerated by using NaCl Solution (10% Brine Sol $NH_4Cl + NaOH \rightarrow NaCl + NH_4OH$)

$$CaZe \text{ (or) } MgZe + 2NaCl \longrightarrow Na_2Ze + CaCl_2 \text{ or } (MgSO_4)$$

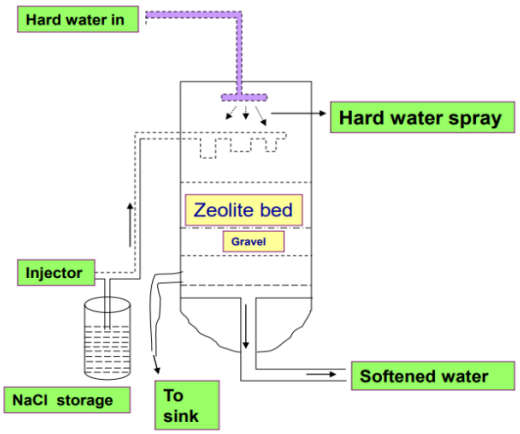
Used Zeolite

10% brine solution

Regenerated Zeolite

Washings drained

Zeolite softener



Advantages / Merits of Zeolite process

1. It automatically adjust itself according to hardness of water.
2. Soft water of 10-15 ppm can be produced by this method
3. The equipment is cheap and occupies less space
4. It does not require more time and skill

Disadvantages / Limitations / Demerits of Zeolite process

1. If the water is turbid than output is reduced.
2. Treated water contains more sodium salts.
3. The process cannot be used with highly acidic water.

4. Distinguish between temporary and permanent hardness. Briefly explain the draw backs of hardwater in domestic and industrial use.

Temporary or Carbonate Hardness

- The hardness of water which can be removed by simple boiling.
- Temporary Hardness is caused by the presence of dissolved bicarbonate of calcium and magnesium.

$$\underset{\text{Calcium bicarbonate}}{Ca(HCO_3)_2} \xrightarrow{\text{Heat}} \underset{\text{Calcium Carbonate}}{CaCO_3} + H_2O + CO_2$$

$$\underset{\text{Magnesium Bicarbonate}}{Mg(HCO_3)_2} \xrightarrow{\text{Heat}} \underset{\text{Magnesium hydroxide}}{Mg(OH)_2} + 2CO_2$$

Permanent Hardness

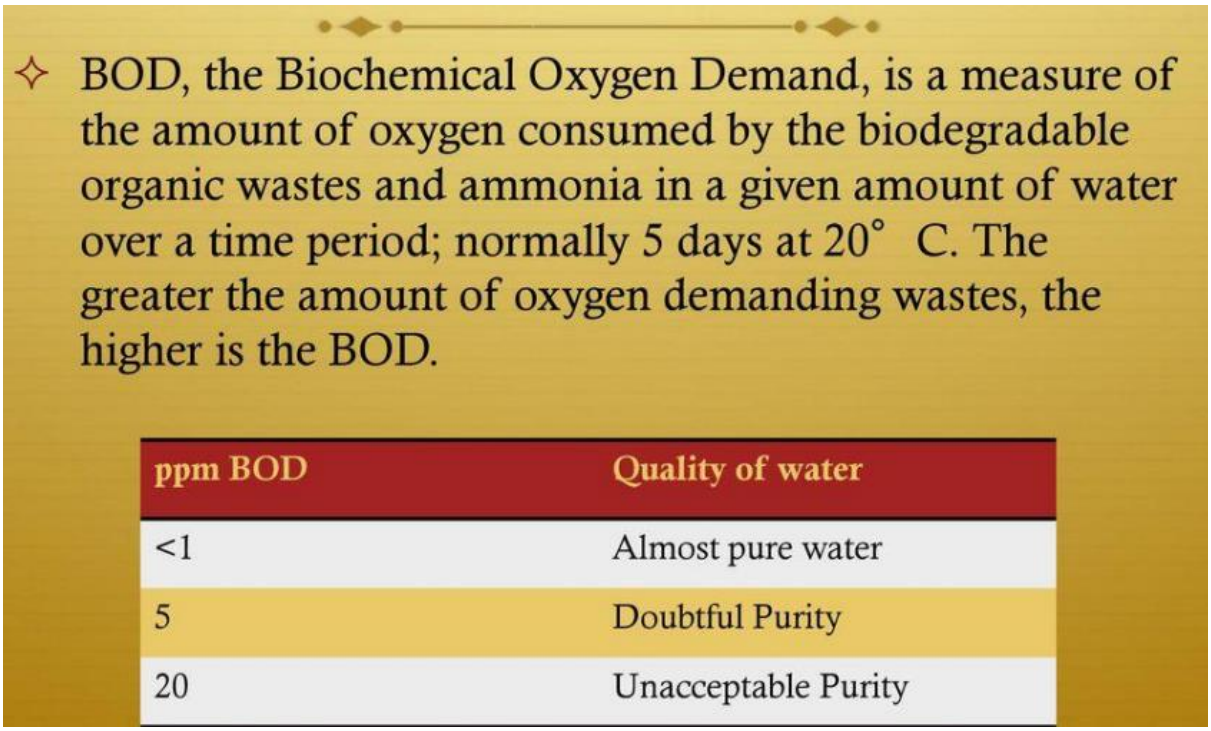
The hardness of water which cannot be removed by simple boiling is called permanent hardness.

It is due to the presence of chlorides, sulfates of calcium and Magnesium.

Note: This hardness can be removed by some external methods i.e. Zeolite Method, Ion Exchange Method, Lime Soda Process etc.

note:-for 2nd part refer to question 2

5. **Define the term BOD.**



- BOD, the Biochemical Oxygen Demand, is a measure of the amount of oxygen consumed by the biodegradable organic wastes and ammonia in a given amount of water over a time period; normally 5 days at 20° C. The greater the amount of oxygen demanding wastes, the higher is the BOD.

ppm BOD	Quality of water
<1	Almost pure water
5	Doubtful Purity
20	Unacceptable Purity

BOD

- Biochemical oxygen demand (BOD) is the amount of dissolved oxygen needed by aerobic biological organisms in a body of water to break down organic material present in a given water sample at certain temperature over a specific time period.

- The term also refers to a chemical procedure for determining this amount. This is not a precise quantitative test, although it is widely used as an indication of the organic quality of water.[1]

- The BOD value is most commonly expressed in milligrams of oxygen consumed per litre of sample during 5 days of incubation at 20 °C and is often used as a robust surrogate of the degree of organic pollution of water.

6. Simplify boiler feed water and briefly describe about scale, sludge, foaming, and priming problems in boiler.

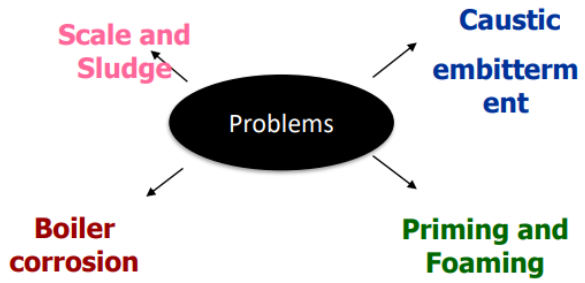
Boiler Feed Water

"The water mainly used in boilers for steam generation is known as boiler feed water".

For such water we need some specification:

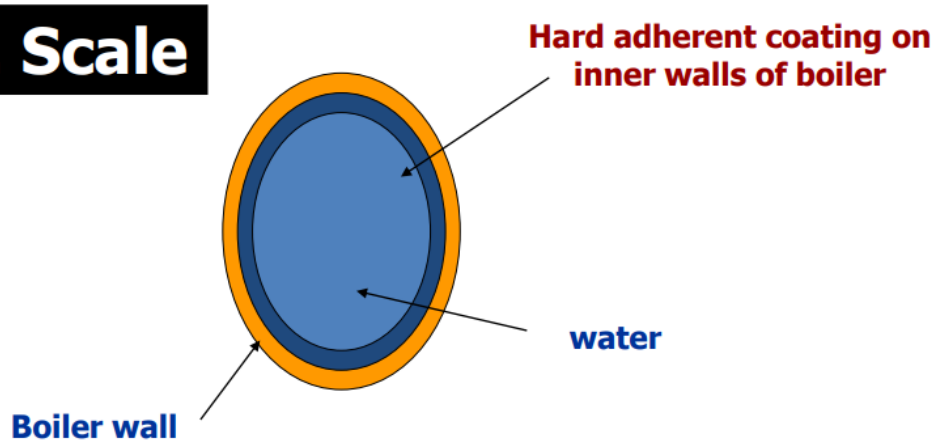
- **Hardness should be below 0.2 ppm**
- **Its caustic alkalinity (due to OH^-) should be in the range of 0.15 – 0.45 ppm.**
- **Its soda alkalinity (due to CO_3^{2-}, HCO_3^-) should be in the range of 0.45 – 1.0 ppm.**

Excess of above impurities cause the following problems-



Boiler problems

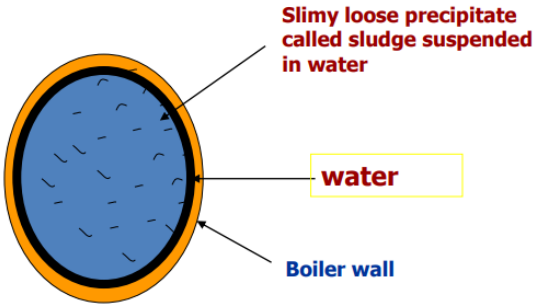
1. Scale



- Scales are hard deposits firmly sticking to the inner surface of the boiler. Scale may be formed inside the boiler due to decomposition of calcium-bicarbonate [$Ca(HCO_3)_2$].

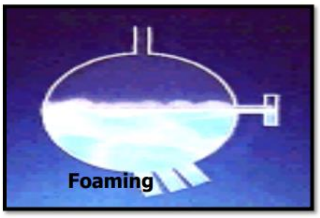
$$Ca(HCO_3)_2 \xrightarrow{\Delta} CaCO_3 \downarrow + H_2O + CO_2 \uparrow$$

1. Sludge

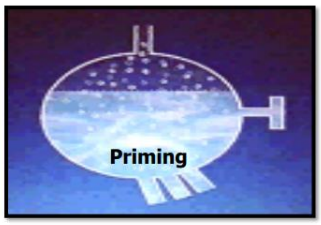


Sludge is a soft, loose and slimy precipitate formed within the boiler. It can be easily scrapped off with a wire brush.

II. Priming and foaming



Foaming- It is the production of continuous foam or hard bubbles in boilers. Foaming is due to the presence of substance like oil in boiling water.



Priming- It is the process in which some particles in water are carried along with the steam. The resulting process is called as wet steam or carry over. The process of formation of wet steam in boilers is called as priming.

Causes of Priming,

1. Presence of dissolved salts
2. High velocity steam due to sudden boiling
3. Improper boiler design

III. Caustic embitterment

❖**Boiler corrosion which takes place due to presence of highly alkaline water in boiler is known as caustic embrittlement**

$Na_2CO_3 + H_2O \longrightarrow NaOH + H_2O$

$Na_2CO_3 + H_2O \longrightarrow 2NaOH + H_2O$

$2NaOH + Fe \longrightarrow Na_2FeO_2 + H_2O$

$3Na_2FeO_2 + 4\,H_2O \longrightarrow 6\,NaOH + Fe_3O_4 + H_2$

IV. Boiler corrosion

Degradation or destruction of boiler materials (Fe) due to the electrochemical attack is called boiler corrosion

7. Define the term COD.

COD

- COD (Chemical Oxygen Demand) is the amount of oxygen required to degenerate all pollutants in a chemical way (by adding oxidising agents and heating). In general with chemical destruction you can remove more pollutants than with the biological way.

- . It is expressed in milligrams per liter (mg/L) also referred to as ppm (parts per million), which indicates the mass of oxygen consumed per liter of solution.

8. Solve the scaling problem with the help of Calgon conditioning method discuss it with suitable justification.

Prevention of scale formation

Internal conditioning methods - of boiler water to prevent scale formation

1. **Colloidal conditioning – spreading of organic compounds like tannin, agar gel**
2. **Carbonate conditioning – addition of carbonate compound**
3. **Phosphate conditioning – addition of phosphate compound**
4. **Calgon conditioning – addition of sodium hexa meta phosphate**

4. Calgon conditioning

- Calgon conditioning is a most useful method to remove hardness products (i.e. scale & sludge) from boiler.
- In this process the **Graham's salt** is used. Graham's Salt is also known as **Calgon (sodium hexa metaphosphate).**
- Calgon (**sodium hexa metaphosphate)** is soluble in water and it converts the impurity like $CaCO_3$, $CaSO_4$ into soluble complex compound, which will remain in dissolved form in water. This property helps to remove the scale and sludge.

4. Calgon conditioning continue....

$$Na_2[Na_4(PO_3)_6 \rightleftharpoons 2Na^+ + [Na_4P_6O_{18}]^{2-}$$

sodium hexa meta phosphate

$$2CaSO_4 \text{ (Boiler water)} + [Na_4P_6O_{18}]^{2-} \longrightarrow [Ca_2P_6O_{18}]^{2-} + 2Na_2SO_4$$

Calcium Sulfate

Soluble complex ion of calcium - can be removed easily

Calgon tablets are used in the cleaning of washing machine drums

9. Distinguish between Zeolite softener and and ion exchange process and its advantages and disadvantages.

Comparison of Zeolite Process and Ion Exchange process

Zeolite Process

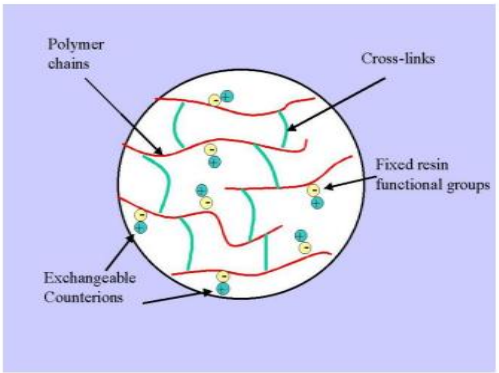
- Advantages
  1. It automatically adjust itself according to hardness of water.
  2. Soft water of 10-15 ppm can be produced by this method
  3. The equipment is cheap and occupies less space
  4. It does not require more time and skill
- Disadvantages
  1. If the water is turbid than output is reduced.
  2. Treated water contains more sodium salts.
  3. The process cannot be used with highly acidic water.

Ion Exchange Process

- Advantages
  1. The process can be used to soften highly acidic or alkaline waters
  2. It produces water of very low hardness of 1-2ppm. So the treated waters by this method can be used in high pressure boilers
  3. It removes both types (cationic & anionic) of hardness impurities.
- Disadvantages
  1. The setup is costly and more expensive Chemicals are required.
  2. It requires more time and space.
  3. If turbidity is present output is reduced.

10. Identify how cation and anion exchange process used for the treatment of hard water. Mention its advantages and disadvantages.

Ion-Exchange resin



Ion exchange resin

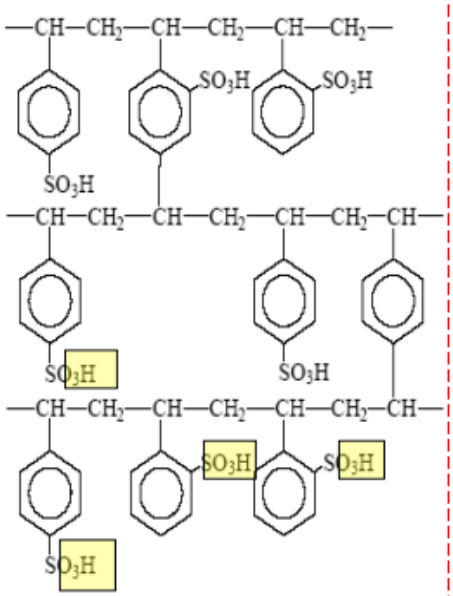
Ion exchange resins are insoluble, cross linked, long chain polymers having functional groups responsible for the "ion-exchange" properties.

Types of Ion Exchange Resins: Two types

Cation Exchange Resins	Anion Exchange Resins
• These resins containing acidic functional groups (i.e. -COOH, $-SO_3H$ etc.) which are capable of exchanging their H^+ ions with Hardness producing cations. • These are denoted by $R^- H^+$. • **Example-** Zeocarb, Dowex-50 etc.	• These resins containing basic functional groups (i.e. quaternary ammonium group) which on hydrolysis becomes capable of exchanging their OH^- ions with hardness producing anions. • These are denoted by $R^+ OH^-$. • **Example-** Dowex–3, Amberlite – 400 etc.

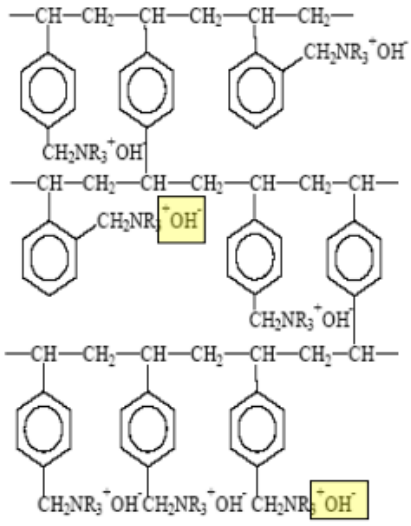
Structure of Cation and Anoin exchange resins

Cation exchange resin



A strongly acidic sulphonated polystyrene cation exchange resin

Anion exchange resin



A strongly basic quaternary ammonion anion exchange resin

R = CH_3

Regeneration of ion exchange resins

cation exchange resin is treated with acid (dil HCl or dil H_2SO_4) and anion exchange resin is treated with a base (NaOH) solutions to regenerate these resins

Regeneration of Cation exchange resin

$R_2Ca^{2+} + 2H^+$ (dil. HCl (or) H_2SO_4) $\longrightarrow$ $2\,RH^+ + Ca^{2+}$ ($CaCl_2$,washings)

Regeneration of Anion exchange resin

$R_2SO_4^{2-} + 2OH^-$ (dil. NaOH) $\longrightarrow$ $2\,ROH^- + SO_4^{2-}$ (Na_2SO_4, washings)

Regeneration of ion exchange resins

cation exchange resin is treated with acid (dil HCl or dil H_2SO_4) and anion exchange resin is treated with a base (NaOH) solutions to regenerate these resins

Regeneration of Cation exchange resin

$R_2Ca^{2+} + 2H^+$ (dil. HCl (or) H_2SO_4) $\longrightarrow$ $2\,RH^+ + Ca^{2+}$ ($CaCl_2$,washings)

Regeneration of Anion exchange resin

$R_2SO_4^{2-} + 2OH^-$ (dil. NaOH) $\longrightarrow$ $2\,ROH^- + SO_4^{2-}$ (Na_2SO_4, washings)

Unit2: (CO2) :

1. Inspect the waste in brief. Classify the waste according to their origin and type.

Wastes (also known as **rubbish**, **trash**, **refuse**, **garbage**, **junk**, **litter**) is unwanted or useless materials. In biology, waste is any unwanted substances or toxins that are expelled from living organisms and metabolic waste such as urea and sweat.

Waste is defined as **unwanted and unusable materials** and is regarded as a substance which is of no use. Waste that we see in our surroundings is also known as garbage. Garbage is mainly considered as a solid waste that includes wastes from our houses (domestic waste), wastes from schools, offices, etc. (municipal wastes) and wastes from industries and factories (industrial wastes).

source of waste-

a)household

b)commercial and industrial

classification of waste

-> Waste can be solid, liquid and gas or waste heat. Waste is classified by its source and by its characteristics. Waste products can be differentiated according to their source and types.

-> Generally there are four sources from where waste can be generated such as **industrial, municipal, biomedical and electronic**. Waste can be classified on the basis of different criteria such as based on matter, based on degradation feature, based on environmental impact and based on the source

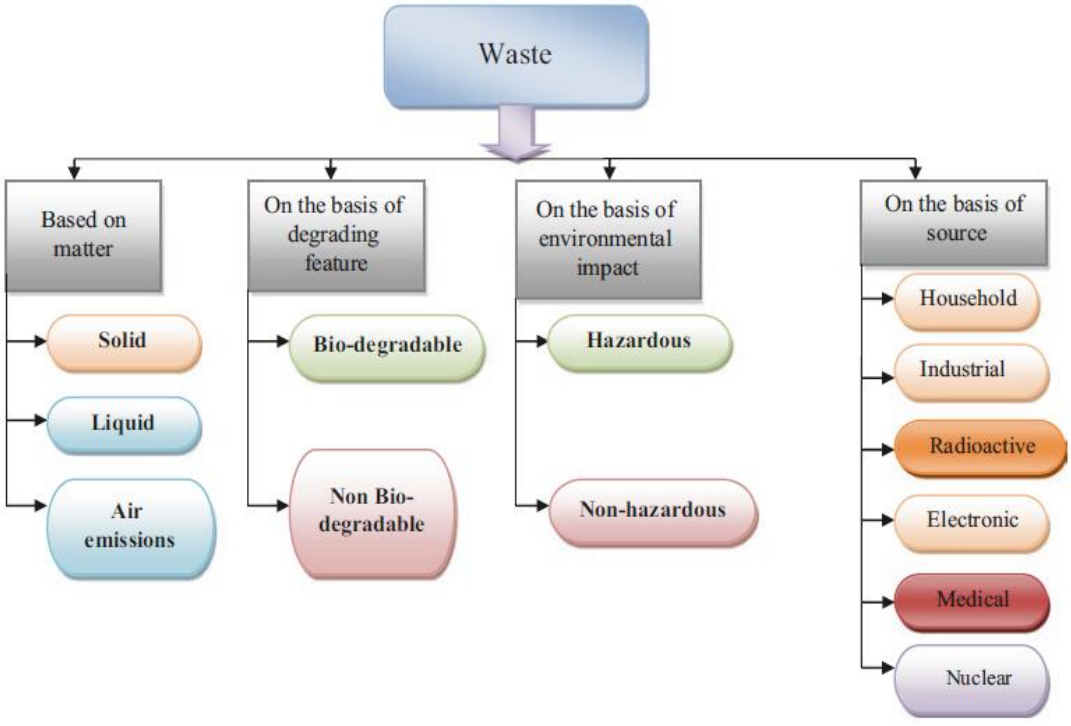


Fig. 1 Different types of waste

classificatiion of waste acc. to there properties-

a)bio-degradable-paper,woods,fruits

b)non-biodegradable-plastic,can,machines

Classification of Wastes according to their Effects on Human Health and the Environment

- **Hazardous wastes**
- **Substances unsafe to use commercially, industrially, agriculturally, or economically and have any of the following properties- ignitability, corrosivity, reactivity & toxicity.**
- **Non-hazardous**
- **Substances safe to use commercially, industrially, agriculturally, or economically and do not have any of those properties mentioned above. These substances usually create disposal problems.**

real ans

Classification of wastes according to their origin and type

- **Municipal Solid wastes:** Solid wastes that include household garbage, rubbish, construction & demolition debris, sanitation residues, packaging materials, trade refuges etc. are managed by any municipality.
- **Bio-medical wastes:** Solid or liquid wastes including containers, intermediate or end products generated during diagnosis, treatment & research activities of medical sciences.
- **Industrial wastes:** Liquid and solid wastes that are generated by manufacturing & processing units of various industries like chemical, petroleum, coal, metal gas, sanitary & paper etc.
- **Agricultural wastes:** Wastes generated from farming activities. These substances are mostly biodegradable.
- **Fishery wastes:** Wastes generated due to fishery activities. These are extensively found in coastal & estuarine areas.
- **Radioactive wastes:** Waste containing radioactive materials. Usually these are byproducts of nuclear processes. Sometimes industries that are not directly involved in nuclear activities, may also produce some radioactive wastes, e.g. radio-isotopes, chemical sludge etc.
- **E-wastes:** Electronic wastes generated from any modern establishments. They may be described as discarded electrical or electronic devices. Some electronic scrap components, such as CRTs, may contain contaminants such as Pb, Cd, Be or brominated flame retardants.

2. Identify the sanitary landfill for control of domestic waste.

   A sanitary landfill is a pit with a protected bottom where trash is buried in layers and compressed to make it more solid

   How Sanitary Landfill Works?

   Sanitary landfills operate by layering waste in a large hole. There are different levels of layering of waste to facilitate the decomposition of the materials as well as trap toxic gases released from the process. The layers are made in such a way that the bottom part has the smallest volume, with the top part taking the bigger volume to avoid collapsing of the land.

   The first layer is the liner system.
   The second layer is the drainage system.
   The third layer is the gas collection system
   The fourth layer contains the trash itself

3. Identify the process of incineration for controlling urban waste.

4. Identify the e-waste. Is e-waste hazardous, enumerate the different source of e-waste.

5. Utilize the process of pyrolysis for controlling industrial waste.

6. Inspect the different constituents of e-waste. Why disposal of e-waste is necessary.

7. Simplify the biomedical waste. Discuss the different categories of biomedical waste and its disposal.

8. Organize the major impacts of solid waste on aquatic life.

9. Identify; how solid waste could be reduced and managed.

10. Explain the different techniques of waste disposal.

11. Illustrate the various consequences associated with solid waste.